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Prof. Emad Elbeltagi

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About the journal

International Journal of BIM and Engineering Science (IJBES) is an international, peer reviewed journal, publishing high-quality, original research.

Aims & Scope

IJBES aims to provide researchers and experts with up-to-date research in BIM and its relation with Engineering Science, and to facilitate the global exchange and review of research, ideas and expertise among individuals in the scientific community.

IJBES publishes original peer-reviewed research papers, case studies, technical notes, book reviews, features, discussions and other contemporary articles that advance research and practice in **Building Information Modeling** in architectural, engineering, and construction management, advance integrated design and construction practices, project lifecycle management, and sustainable construction. The journal's scope covers all aspects of **architectural design, design management, construction/project management, engineering management of major infrastructure projects, and the operation and management of constructed facilities**. IJBES also addresses the **technological, process, economic/business, environmental/sustainability, political, and social/human developments that influence the construction project delivery process**.

IJBES strives to establish strong theoretical and empirical debates in the above areas of engineering, architecture, and construction research. Papers should be heavily integrated with the existing and current body of knowledge within the field and develop explicit and novel contributions. Acknowledging the global character of the field, we welcome papers on regional studies but encourage authors to position the work within the broader international context by reviewing and comparing findings from their regional study with studies conducted in other regions or countries whenever possible

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Editorial Statement

It's a pleasure to present the **first** issue in the **third** volume for International Journal of BIM and Engineering Science (IJBES) in **Jun. 2020**. IJBES is one of the scientific journals that BIMarabia s.r.o publish. BIMarabia is a publisher of peer-reviewed, open access academic journals and books. BIMarabia aims to provide researchers, professors and students with up-to-date research in BIM and its relation with Engineering Science, and to facilitate the global exchange and review of research, ideas and expertise among individuals in the scientific community. Established in 2015, BIMarabia has attracted over 20000 scientists worldwide. All content published by BIMarabia offers unrestricted access, and distribution, in any medium; provided the original work is correctly cited. We ensure the highest standards of peer-review for all manuscripts submitted for publication, thanks to the highly qualified scientists who are members of our journal's Editorial Board. BIMarabia delivers support throughout the complete publishing process in an efficient and effective manner.

Architectural, Engineering and Construction (AEC) industry has a giant influence in different nations' economic growth, however, it suffers from myriad problems. AEC industry projects faced issues such as being behind schedule, over budget, inferior quality, low productivity, without sustainability and more. The key players wandered about technology, methodology, or tools that can mitigate or solve these problems. Several researchers and professionals prove that Building Information Modelling (BIM) could help in solving the AEC industry problems. Despite there is no consensus about the definition of BIM; researchers and professionals recognize and appreciate the benefits of using BIM.

Therefore, IJBES concerns about BIM and the related and relevant engineering Science. The **second** volume, **Second** issue, contains two articles. The first one deals with **Practical approach for paving the way to motivate BIM non-users to adopt BIM**. Whereas the second one discusses **A Comparative Review of Building Information Modeling Frameworks**.

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Influence of Partnering Agreements Associated with BIM Adoption on Stakeholder's Behaviour in Construction Mega-Projects

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Abstract:

Construction mega-projects are typically associated with cost overruns and time delays due to conflicts of interest between diverse stakeholders. This research investigates the influence of the partnering approach and the adoption of Design and Build (D-B) contractual agreement on the behaviour of stakeholders on mega-projects. Through a case study, the significant factors that influence stakeholder management are appraised, such as cooperation, developing trust, and a dearth of communication. The research concluded that mutual trust, transparency, leadership, the well-defined scope of work, a clear definition of responsibilities, collaboration, and training are the main success factors of partnering projects. The research also emphasised that Building Information Modelling (BIM) plays a vital role to secure the mentioned key successful factors for partnering. Furthermore, BIM facilitates achieving project objectives with the adoption of D-B contracts. This research contributes to the developing body of knowledge addressing the application of partnering in construction. The outcomes of this research will be beneficial for clients, contractors, project managers, and contract managers when taking into account future execution plans for D-B projects. Forthcoming studies can develop a framework to combine various stakeholders to obtain optimum satisfaction.

Keywords: BIM; Building Informatioion Modelling; partnering; stakeholders; design and build; construction industry; organisation behaviour

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1. Introduction:

Design-Build Institution of America (DBIA) defines "Design-Build as a method of project delivery in which one entity (the Design-Build Entity) forges a single contract with the Owner to provide the architectural, engineering and construction services" (DBIA, 2019). The goals of this study are to identify Critical Success Factors (CSFs) for 'partnering' a project through D-B contracts and to investigate the influence of partnering on the behaviour of stakeholders on mega construction projects.

Project delivery systems (PDS) include the traditional method of procurement, where the owner employs a consulting firm to design a project and then grants the construction contract to the main contractor (or constructor) to construct the project following that design (Wu and Barnes 2016). The traditional method is of utmost widespread for small-scale and local projects, whereas the most popular procurement scheme for large-scale, mega-projects are those based on either D-B, or on an Engineering, Procurement, and Construction (EPC) method (Lin and Chen, 2004). D-B contract, the contractor is liable for both the design of the construction project then executing the construction according to contractual specifications (Mashali et al., 2019; Du et al., 2016). EPC contracts, a sole contractor is liable for the entire engineering design, construction, and procurement of a project on a turnkey ground.. Collaborative procurement methods have been gaining impetus in numerous developed countries (Hamzeh et al., 2019; Mashali et al., 2020a).

Mega-projects, in other word mega construction projects, are commonly associated with cost overruns and time delays. Construction mega-projects can be defined as; complex and large-scale ventures which budgeted more than or equal USD 1 billion, including private and public stakeholders (Flyvbjerg, 2014). International Construction Mega-Projects (ICMPs) complexity and the scope of work involves various stakeholders such as international consultants, multinational contractors, joint-ventures, together with several design and construction teams. The Project Management Institute, PMI A. (2017) defines a stakeholder as: "an individual, groups, or organisations who may affect, be affected by, or perceive themselves to be affected by a decision, activity, or outcome of a project."

ICMPs require interactive coordination for success. However, the construction industry has been usually characterised as fragmented, leading to low performance, and frequently accompanied by adversarial relationships between project stakeholders (Kadefors, 2004; Eriksson, 2010; Eriksson and Laan, 2007). In the traditional project procurement method, a competitive tendering process, where the client's principal election standard is based on the bid price, is applied to grant the contract, typically to the lowest bidder. This situation results in a lot of pressure on the construction projects' key stakeholders, such as the contractor, for numerous causes; for instance, the unbalanced risk allocation in contract provisions. The method in itself establishes a conflict between owner, consultant, and contractor as each

stakeholder tries to minimise their risk and maximise their benefits. The competitive and price-driven mechanism was deemed the main cause of project failure (Eriksson, 2010). Conflict of interest among the industry stakeholders typifies the negative sides of industry relationships, such ineffective communication, insufficient co-operation, spreads a "win-lose" behaviour and lack of mutual trust (McAllister, 1995; Larson, 1995; Naoum, 2003). Resulting outcomes are cost overruns, poor quality, less productivity, lack of earned value, substandard workmanship, low satisfaction among stakeholders, schedule delays, and mostly litigations (Chan et al., 2004; Egan, 1998; Larson and Drexler, 1997; Ng et al., 2002; Venselaar et al., 2015). Consequently, alternate delivery organisations have evolved to cater to this need.

A need has arisen to change the negative culture among construction industry partners and to perfect the relationship amongst key stakeholders as an attempt to increase the total performance of the construction industry. Latham (1994) and Egan (1998) in the UK, as well as Institute, C.I., (1991) in the USA addressed many stakeholder conflicts and construction industry issues and endorsed the implementation of additional co-operative operational strategies, stakeholder management methods that integrate the project delivery supply chain and resolution of the conflicts of interest between stakeholders that are primarily contractual type conflicts. Modern methods, such as partnering was presented to confront shortfalls that arise from traditional procurement and to enhance performance (Eriksson, 2010; Bygballe et al., 2010; Bellini et al., 2016). Partnering, sometimes referred to as alliancing, can be defined as "a long-term commitment between two or more organisations to achieve specific business objectives by maximising the effectiveness of each participant's resources" (Institute, C.I., 1991; Yeung et al., 2007). Partnering has been effectively applied in some other industries before being proposed into the construction industry (Bygballe et al., 2010; Cheung et al., 2003; Dainty et al., 200; Kim et al., 2010).

Therefore, all stakeholders should coordinate with each other to work collaboratively to facilitate a creative and innovative resolution and rethinks to relinquish the outdated methods that are no longer the appropriate ways and Keep up with the latest technologies. Furthermore, this will assist in achieving the projects' aims and objectives to meet the client and user satisfaction (Ahmed, S., et al., 2018; Elhendawi, A.I.N., 2018). BIM is deemed as an environment that effectively combines all liabilities and endeavours from all project stakeholders through diverse project phases to deliver a functional sophisticate and innovative product replying all parties and project objectives (Elhendawi, A., et al., 2019).

Therefore, this paper investigates the influence of the partnering approach and the adoption of D-B contracts on stakeholders' behaviours on the mega-projects with studying the impact of using BIM technology.. Thus, the general goal is to investigate the contractual setting and explore the extent of the impact of partnering procurement delivery, represented by the D-

B contract, on construction project stakeholder. A case study in Qatar is chosen to achieve the aim of the research.

2. Literature review:

Partnering in construction has been investigated considerably in the last two decades. Two areas of partnering that are directly relevant to stakeholder management in construction projects are CSFs and the Critical Failure Factors (CFFs) (Hong et al., 2012; Aarseth et al., 2012; Bygballe et al., 2010; Li et al., 2005). Challender et al. (2016) specified a group of factors based on a critical review and employed these critical factors to survey building industry experts in the UK. Black et al. (2000) research revealed that the factors influencing partnering in construction projects are 'relationship factors'; that is, commitment from senior management, mutual trust, and effective communication. Chan et al. 2004; Chan et al. 2003a; Miller et al., 2000; Bayliss et al., 2004) - related studies in Hong Kong - indicated that the five frequent CSFs were (1) conflict resolution; (2) establishment; (3) obvious definition of responsibilities; (4) regular monitoring of partnering processes; and (5) readiness to share resources among project stakeholders. Brown et al. (2001) introduced additional factors such as (1) training and preparation; (2) equity; (3) defining of stakeholder's expectations and limitations; (4) development of mutual goals; (5); and (6) leadership. While Hawke (1994) examined factors (reasons) leading to partnering failure in Australia. Key factors identified were: (1) inefficient problem resolution processes; (2) lack of leadership; (3) absence of adequate training; (4) lack of honest and transparent communication between stakeholders; and (5) insufficient commitment to partnership arrangement (Chan et al., 2003b; Chan et al., 2004; Gadde and Dubois, 2010; Wøien et al., 2016).

Adnan et al. (2012). agreed that partnering might not constantly be an accurate resolution to the construction industry's difficulties as it did not essentially eliminate the conflict of interest between stakeholders at the source. Dulaimi et al. (2010) and Ustadi (2013) documented various factors participating in the failure of public-private partnership projects; the factors were: (1) absence of suitable skills in the consortium; (2) high risk; (3) high participation costs; (4) lack of credibility; (5) poor communication between private partners; (6) demands on management time; and (7) long procurement and negotiation processes.

Bresnen and Marshall (2000b) considered two issues leading to partnering collapse. The first matter was the 'one-off' nature of the numerous stakeholders' relations, such as the client and main contractor relations (Mashali et al. 2020b; Hosseini et al., 2016). The second matter was partners preserving their adversarial position. To achieve optimal performance, trust, and "long-term" relations between the stakeholders are essential, (Brown et al., 2001; Mashali et al., 2019; Wong et al., 2008). Wolstenholme (2009) found that "distrust" is chronic and longstanding in the construction projects and that trust is hard to set-up between

stakeholders, mostly because of adversarial relations and disputes between stakeholders (Wong and Cheung, 2004).

Hawke (1994) censured owners for adopting a "cost-driven" schema and for upholding a "win-lose" position when negotiating with main constructors: both of these actions contradict partnering principles. Wood and Ellis (2005), in his review of the progress, indicated that as the market situation deteriorates, particular owners are guided by their "cost-oriented" advisors to relinquish partnering engagements and return to traditional competitive tendering. Bresnen and Marshall (2000a) pointed out the gap between decisions and intentions at the organisation level and stakeholder's behaviour at the project level.

Challender et al. (2019) explored the concept of 'trust' in construction procurement strategies, it examined to the extent of trust influences, within co-operative working arrangements, on the success of co-operative working practices, covered the effect of "trust-building" approaches has on collaborative working environment and partnerships. Kadefors (2004) also discussed the constitutes best practice and how 'trust' in co-operative procurement practices affects the success of construction projects.

Several researchers argued that applying BIM proved benefits which paving the way to successful partnering hereinafter: clash detection, time-saving, improving the quality and reduced rework, increasing efficiency, improving collaboration, coordination and communication, creation and sharing information ability, improving visualisation, reducing the number of requests for information, eliminating claim and law issues, early client involvement, improvement of decision making, enhancing creativity and innovations, overcoming the geographical distance barriers, and helping procurement (Shaban, M.H. and Elhendawi, A., 2018; Elhendawi, A., et al., 2019).

While there is a little literature concerning the influence of partnering on the stakeholders in the construction industry, and only narrow research papers about "Public-Private Partnership" (PPP) projects. While, (Khalifa et al. (2015); Dulaimi et al. (2010); and Alhashemi, (2008)) highlighted that influence was limited but still immature; there is a little research that investigates the influence of partnering on stakeholders in mega construction projects.

3. Research Methodology:

A case study is adopted as a research methodology. This approach allowed the examination of critical topics, understandings, attitudes, and behaviours of various key stakeholders inside the environment of a partnering project. One case study is selected to represent partnering in a mega infrastructure project in Qatar. The challenges in the project are explored, allowing possible developments to be identified for application in a broader built

environment. The study involves a questionnaire in which the questions are built on the conclusions of the literature examination and concentrated on accomplishing the objectives of the research (Farrell et al., 2016). The questionnaire is divided into four divisions: the first involves the background, the second is concerned with the contractor's organisation, the third focuses on the implementation phase of the project, and the last division focuses on the interviewees' perception and assessment of the experience in partnering agreements or contracts.

Sample size is important to obtain representative results. The population of this study comprised construction engineering practionaires and academics that work on contruction mega-projects. Galvin's equation can be used to find the number of interviews required to have a stated level of confidence (P) that all the relevant themes which are held by proportion (R) of the population will occur within the interview sample (Galvin, 2015) was employed to establish the recomended sample size.

$$n = \frac{\ln(1-P)}{\ln(1-R)} \qquad \text{Equation (1)}$$

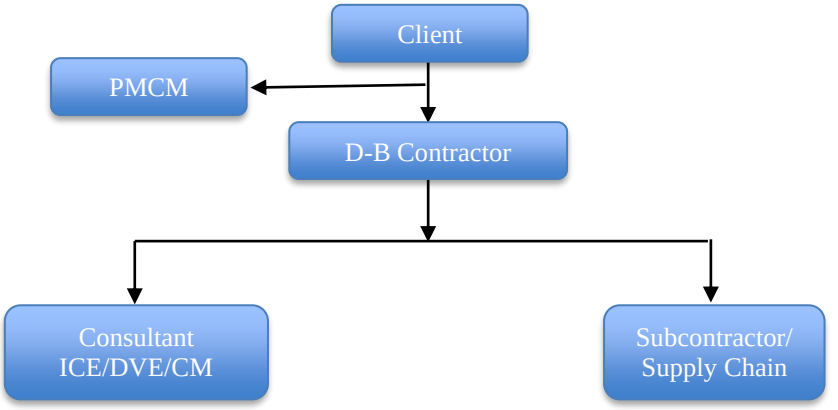
Where n is the recomended recommended number of intervews, P is the confidence factor (> 95%), R is population proportion (10%). Upon calculating Equation 1 using the assumed data ($n = \ln(1-0.95)/\ln(1-.1)$) a sample size of 29 interviewes was determined. To facilitate the analysis of the CSFs, each respondent was asked to rate to what extent he/she agreed/disagreed with each of the main factors influencing partnering, on a five-point Likert scale ranging from 1 to 5, where 5 represents 'Strongly agree', and 1 represents 'Strongly disagree'.

Semi-structured interviews are conducted with a heterogenous cluster consisted of seventy construction experts from various disciplines in architecture, engineering and construction (AEC) industry, such as the client's project manager, the consultant's project manager, the lead architect, the construction manager, the contract manager, the planning manager, the resident civil engineer, and the engineering manager. The researchers used expert judgment to elect professional stakeholders with experience in diverse sorts of industry disciplines, comprising partnering and representing clients, main contractors, and consultant organisations. Consultations between industry experts and the academic researcher were carried out to design and frame the structure and format for the interviews. A "pilot" interview was held to acquire advice on the dataset gathering tools, and tease out any deficiencies with the approach it was administered and designed. However, beyond these two criteria, the sample represents partnering procurement through D-B contracts, and the industry experts agreed that the sample case study was large enough to represent all D-B contracts in Qatar since it adopted this type of contractual agreement in numerous FIFA

2022 World Cup™ and QNVs' 2030 construction mega-projects such as Doha Metro, Lusail LRT, and the New Orbital Highway.

2.1. Case study description

The case study is for an infrastructure mega-project in Qatar. The project comprises more than 37 km of infrastructure works, with an estimated cost of more than USD 6 billion. The planned construction period is five years, divided into multiple design packages and construction phases. The State of Qatar is a leading country in partnering procurement and has a respectable record of delivered projects using DB contracts. A contract was signed between the client and a consortium - led by the main contractor - to "Design and Build" the infrastructure mega-project. The main contractor delivered the resources essential for the appropriate implementation towards the timely completion of the project under study. Contractual relations between the D-B contractual parties is shown in Figure 1.



Legend
PMCM: Project Management Construction Management Contract
D-B Contractor: Design and Build main Contractor
ICE: Independent Checker Engineer
DVE: Design Verification Engineer
CM: Construction Management

Figure 1: The contractual relationship between parties in D-B Contract

The qualitative coding approach was adopted as a sorting basis to categorise the individual words of short phrases and to brief large sections of text (Taylor et al., 2015). Throughout the sorting procedure, coded parts of the text are taken to explain and summarise the raw datasets. Coding and semantic words examples such as "informal engagement"; 'trust'; "collaboration"; "closer interaction"; "good team working"; "ineffective communication"; "leadership"; "transparent"; "disputes"; "honest"; "obstacles"; "stakeholder"; and "effective communication." The raw dataset was summarised in tables, CSFs or CFFs are analysed,

codes and semantic words are listed, data consistency and discrepancies are observed, and suggestions are presented. Table 1 represents a sample of the data analysed; it is arranged to contextualise the "qualitative data" in an organised and presentable way as a base of the discussion and findings narrative.

4. Results and discussions:

The case study findings provided a summary of how 'partnering' is practised in construction mega-projects in Qatar, which was consistent with numerous of the attributes success and failure factors recognised in extant literature. Findings revealed an agreement between the interviewees that D-B contracts improve the performance of project stakeholders and the quality of the work. This was ascribed primarily to the required strict compliance with provisions of the contract and because, in D-B contract, it is in the interest of the main contractor to certify that the quality of work done throughout the construction phase warranties the optimal performance. This ameliorates client satisfaction. It is also agreed that a D-B contract benefits improve the utilisation of resources and maintain certain long-range profits for contract parties. The positive outcomes can also create additional business chances for the main contractor with the client. Participants also reported that the gap between the perceptions of those who have no partnering experience and joined the project; and the behaviour of members that experience the D-B contract at a project level as one of the challenges touching the appropriate execution of 'partnering' approaches on construction projects.

Such an issue could be resolved by conducting appropriate inductions and continuous training and education about the variance between traditional arrangements and 'partnering' projects, and encouraging the new team members to enjoy the healthier relations with their partners' equivalents. If this behaviour and knowledge are not adequately transmitted to the project teams and they sustained to react in the typical confrontational behavioural manners of "traditional contracts", project performance will negatively affect the mutual trust and collaboration between the project stakeholders. Thus, middle and top management should continuously monitor the behaviour of team members and remove any member who is not adaptable to the D-B contract environment or insists on behaving in the confrontational behavioural patterns of traditional contracts.

Table 1. Data to analyse 'partnering' associated with 'BIM' in Qatar's construction industry.

Theme/factors analysed	Observation or proposition	Inconsistency	Similarity
Boost 'trust' and 'collaboration'in 'partnering' agreements	▪ Share ethics based on justice, trust, and fairness among partners are primary. ▪ Cognition-based, system-based and affect-based ▪ Trust reciprocation increases its levels between partners. ▪ Social interaction increases the degree and quality of trust among partners. ▪ Some supply chain partners have a potential lack of trust, more strong partners. ▪ Trust and collaboration may be undermined by negative, adversarial cultures and attitudes.	▪ Trust impacted by organisational contractual position. ▪ Trust created from preceding relations between the contractual parties (especially at top management levels) considered significant.	▪ Unjust working relationship. ▪ 'Abuse of power' negatively impacts the growth of trust. ▪ Human factors, like communication, confidence, commitment, personalities, and teamwork are significant factors for establishing collaboration and trust.
Influence of BIM on 'collaboration' in 'partnering' arrangements	▪ BIM technology enhances the collaboration between the project's stakeholders		▪ BIM adoption enhances collaboration and accordingly improves partnering
Influence of economic prosperity and budget surplus on 'partnering' arrangements	▪ Traditional procurement methods based on a cost-driven approach is not seen by clients as the preferred option. ▪ Owners are not seeking to extend partnering arrangements to disadvantage partners in some situations. ▪ Not to resort to traditional procurement approaches. ▪ More involvement of knowledge among contract partners. ▪ Concentrate on investment that is aiming to support partnering.	▪ Turn to 'partnering' arrangements. ▪ Professional development, training, more increased in times of economic prosperity.	▪ Not reversion to 'traditional procurement' approaches in times economic prosperity, national budget surplus. ▪ Pleasant 'economic climate' enhancing the partnering. ▪ Economic 'austerity' negatively impact partnering
Observed partnering benefits	▪ Collaboration increasing is a significant element to accomplish effective contracts. ▪ The arising need for increasing supply chain integration, and collaboration. ▪ In complex projects, the risks can be specified at the start and managed efficiently. ▪ The benefits of partnering have been over-valued in the present, and the past, so a no balanced view.	▪ Suspicion of realisable benefits by organisations and individuals. ▪ Experiences in quick payment. ▪ Firms perceived vulnerable to exploitation during partnering practices.	▪ Better built environment. ▪ Partnering improved teamwork, cooperation, and collaboration.

Management has to change the organisational culture of the client, contractors, consortium, consultant, and subcontractors before entering into the partnership. For example, it has to be agreed to boost the teams by employing staff with experience in 'partnering' contracts. Instead, the management applied further flexibility over team decisions and behaviour by increasing their decision-making authority and autonomy, while the management focused on leadership. This tactic, while it assisted to resolve disputes among stakeholders amicably (pacifically) at a managerial level - this is one of the declared partnering CSFs in the case study - it did change team behaviour and enhance relationships at a project level. Moreover, the project managers were contented with their reduced authority and new role compared to traditional contracts.

Interviewees agreed that well-defined Scope of Work (SOW), a sharp split of scope and well-defined responsibilities, eliminated the conflicts and improved collaboration at the project level. Thus, improved the performance of project teams and increased client satisfaction. Interviewees all agreed that the importance of management commitment to 'partnering' basis and emphasised the importance of workshops, training, and pre-meetings. Participants also reported that these are 'partnering' CSFs aiming to increase their awareness of "partnering," and educate personnel to maintain appropriate behaviour on a D-B contract. Participants also emphasised the importance of mutual trust among the stakeholders as the main CSFs and its positive impact on the relationship between partners, as shown in Figure 2.

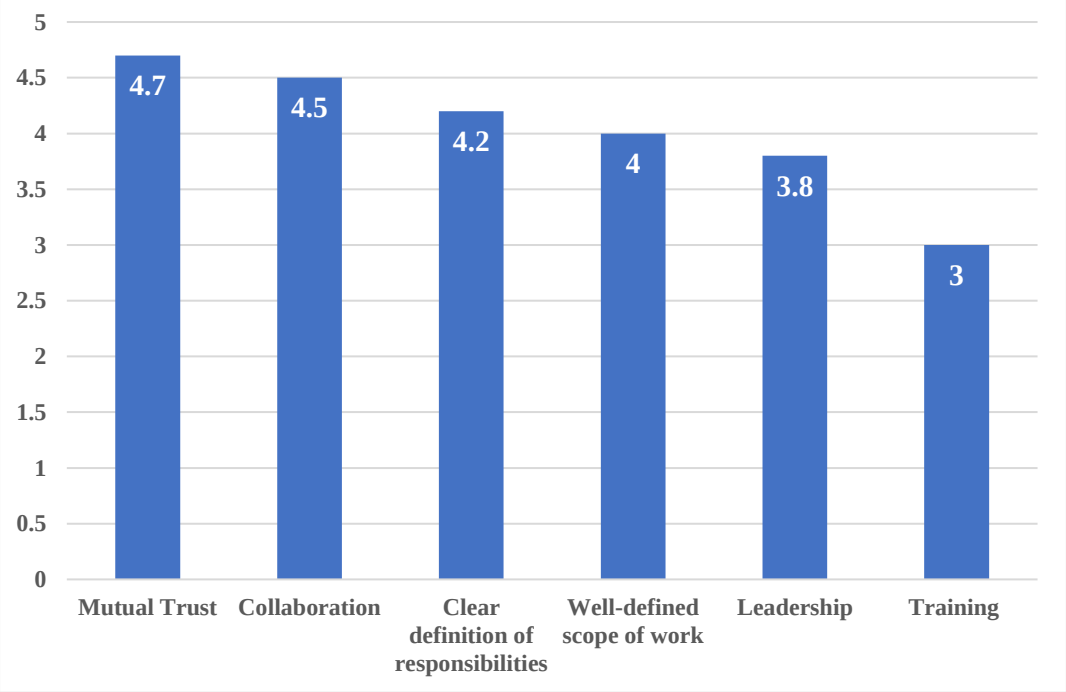


Figure 2: The Main Success Factors of Partnering Projects: Stakeholders influencing

Participants reported that a D-B contract has major differences from traditional projects, which change the nature of the interrelationship and interactions between contract parties. The D-B arrangements turn the client-contractor connection considerably less confrontational. The "mutual interest" of all parties, conjointly the rigorous observing of the activities by several stakeholders, i.e. Project Management and Construction Management (PMCM), Independent Checker Engineer (ICE), Design Verification Engineer (DVE), and lenders and investors, ensures that the works will be fully compliant with standards, contract provisions, and specifications and increase the level of trust and collaboration between all parties.

Interviewees reported that fair risk allocation and risk-sharing between partners was a success factor of partnering. In D-B contracts, clients from public sectors tend to transfer the entire risk to the main contractor (consortium or Joint Venture (JV)). The consortium is then believed in charge of for the appropriate delivery of the D-B agreement in accordance with design, contract provisions, and specifications. The majority of interviewees were of the view that risk on main constructors in D-B contractual agreement could be achieved on account of the long lead time before commencing construction and as the main constructor are engaged early in the investigation and design phases. Hence, D-B contractor should be able to manage and anticipate the vast majority of risks at the onset.

Interviewees claimed that BIM could facilitate mutual trust, transparency, leadership, the well-defined scope of work, clear definition of responsibilities, collaboration, and training which are the main success factors of partnering projects. Therefore, implementing BIM secure successful partnering. This result is lined with what reported in the literature.

In general, this study opinions to offer a potential resolution to deal with the uncertainty and increasing complexity of the construction mega-projects. Indeed, the adoption of 'partnering' contractual agreements as a collaborative working relationship, along with the collaboration between contract parties and project stakeholders, have been recommended as approaches for accomplishing higher benefits in construction mega-projects. It arose from the literature study outcomes from the interviews, which was in line with the literature review by Wong et al. (2008) and other researchers; 'trust' can be distinguished into three different types: cognition-based, system-based, and affect-based. Cognition-based trust is based on understanding and knowledge of the nature of the 'partnering' contractual agreement, while system-based trust is built on performance and faith in the system. Whilst, affect-based trust seems to address the personal emotion and feelings of project stakeholders. Therefore, the project manager must encourage 'trust', and 'collaboration' and must be able to plan a robust system, care for the stakeholders and team members to reinforce those factors.

Whereas, Qatar is one of the developing countries in the Middle East, so the results of this study are applicable in the Middle East and developing countries. Furthermore, The Architectural, Engineering, and Construction industry in Qatar is included several international organisations from several countries all over the world. Thus, the results of this research can be generalised. The research examined the influence of 'partnering' contractual agreement associated with the adoption of modern BIM technology and the nature of the relationship between stakeholders at the planning, design, and construction phases of the construction project and through the entire project life cycle and facility management in construction mega-projects. Furthermore, the research concluded that 'trust', 'collaboration' and the adoption of BIM technology are key success factors of 'partnering' contractual agreement in construction mega-projects. Hence, investigation of the critical success factors through a semi-structured interview by a heterogenous cluster of industry professionals represented the AEC industry that can aid the successful project delivery through 'partnering' agreements with consideration of the impact of BIM technology in the built environment. The research outcomes to provide a good starting point for dialogue for clients, contractors, real-estate developers, key project stakeholders, local authorities, decision-makers, and academics. The critical success factors can be considered as a roadmap to contractors, engineering consultants, clients, and authorities in scheming more robust policies and legal guidelines to improve the "traditional" procurement and spread the adoption of 'partnering' agreements along with BIM and LC initiatives an on a solid basis for Integrated Project Delivery (IPD). The findings of this research can shape the foundation of benchmarks for synergy and maturity of IPD in construction mega-projects.

5. Conclusions:

The construction industry is a domain constantly evolving throughout enhancing the contractual agreements and implementation of creative processes, technologies, and government policies and adopt these in initiatives such as BIM and LC. This research intended to investigate the influence of 'partnering' contractual agreement associated with the adoption of modern BIM technology and the nature of the relationship between stakeholders at the planning, design, and construction phases of the construction project and through the entire project life cycle and facility management in construction mega-projects at the environment of the construction industry. From the literature review and particularly from the performed interviews, it arose that a robust relationship occurs. In specific, the literature review and the interviews presented that particular partnering critical success factors, similar to collaboration, mutual trust, and open transparency, are directly related to stakeholder's behaviours and the successful 'partnering' contractual agreement.

The two critical success factors of partnering projects are 'trust' and "collaboration." Partnering generates a fewer stressful and antagonistic operational environment, supporting superior individual performance. It is also important to note that this research studied the

influence of ‘partnering’ contractual agreements associated with BIM in Qatar the time of “economic prosperity”, and to note that this influence is strongly associated with the economic environment of the country.

Ultimately, the research also indicated that it is consequently recommended that ‘trust’ and ‘collaboration’can be created in encouraging environments, where the progressive environment of this cooperative procedure aligns with the long-term vision of incorporated stakeholders. Thus, enhancing stakeholder relationships reduces disputes, eliminates the conflict of interest, and allows sharing of knowledge, healthy interaction between project stakeholders, and improving problem-solving techniques.

Outcomes of the research have contributed and reinforced the current body of knowledge in ‘partnering’, BIM and LC research cross-field by offering key stakeholders in the construction industry the critical success factors and challenges hindering the ultimate adoption of ‘partnering’, BIM and LC principles in a built environment. Generally, the study's outcomes contribute to and develop the goals of BIM and LC approaches and reinforce the LeanBIM synergy.

The current study can be developed in future researches by assessing the barriers, challenges and critical failure factors to the adoption of ‘partnering’ associated with BIM and LC such as abuse of trust, lack of collaboration, lack of transparency and impact of economic austerity in a country by country basis. Likewise, further researches evaluating a piloted case study construction project, expanding the scope of critical success factors identified through this study, and it starts to new potential research development. In specific, additional studies should surpass the boundaries of this research; for instance, a greater sample of interviews, surveys, and quantitative research methodologies should be involved in the and the analysis should also be expanded outside Qatar.

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Analysis of Barriers and Drivers for BIM Adoption

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Abstract:

Research on 'digitalization and collaboration' in the construction industry has been gaining momentum in the recent academic engagements. Despite its existence in many industries (i.e. financial services, retailing, publishing and travelling) for over ten years, it is yet to catch up by the construction market; this is due to several challenges whose existence are more dynamic and contextual than generic to various countries. The problems are defined in many studies across borders, but their impacts varied with countries. This case is equally the same to drivers toward the adoption of BIM. This study analyses barriers and drivers to BIM adoption in the Nigerian construction industry from adopters and non-adopters perspectives as to allow an informed decision in developing a strategy for macro BIM adoption. Primary data fetched from professional stakeholders through an online questionnaire survey were analysed using SPSS software and Microsoft Excel. This investigation reveals the most significant barriers against BIM adoption as Lack of expertise, Lack of standardization and protocols to mention but a few. And, most influential drivers from both adopters and non-adopters as Availability of trained professionals to handle the tools, Proof of cost savings by its adoption, BIM Software affordability, and awareness of the technology among the industry stakeholders. The adopters and non-adopters groups have nearly equal Percentage Disagreement (PD) and Percentage Agreement (PA) for both the barriers and drivers to BIM adoption. Thus, this suggests that the adopters are still at the early stage of BIM adoption, so have nearly the same perceptions with the non-adopters. The study recommends proper consideration of the established barriers and drivers while developing any strategy for effective BIM adoption. Further face-to-face (interview) study is necessary to explore more and in-depth challenges to adoption of BIM in the industry; and as the industry is getting more aware of the BIM, periodic evaluation of the critical barriers and drivers is vital.

Keywords: BIM adoption; BIM barriers; BIM drivers; construction industry; Nigeria.

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1. Introduction:

Building Information Modelling (BIM) is a digital model representing physical and functional characteristics of building or infrastructure (BIM Industry Working Group 2011). Chartered Institute of Builder (CIOB) described the fundamental idea behind the BIM as to create and share the right information at the right time throughout the design, construction and operation of a building or facility to improve efficiency and decision making. This new paradigm shift in the construction industry is gaining high recognition both in the academic discuss (research) and the industry (application). However, its universal adoption is facing common challenges but yet persistent within the industry and across the world. These challenges are more the same rather than different; although their significance and uniqueness vary with country. On the other hand, the drivers that facilitate its adoption have a similar trend with the barriers.

The BIM is similar to other technologies or innovations; it comes with challenges and barriers while adoption and implementation (McAdam, 2010). Barnes and Davies (2015) revealed the most perceived barriers against BIM adoption by organizations as an issue of readiness, high cost of training, and cost of technology investment (hardware and software). This readiness could be the ability to agreeing to change (i.e. awareness driven) or technology and human resources readiness. The construction industry is widely known to be conventional and resistive to changes (Walasek and Barszcz, 2017); although, this new technological process has come to stay.

Eadie et al. (2014) worked on the identification of barriers to BIM adoption and their order of importance, this study reveals so much to the UK BIM adoption strategy and more importantly directing to the most significant barriers to allow adopters pay more attention to them. However, solving one or more barriers without considering the rest may not bring the end to the challenges on adoption (Lindblad, 2013). Studies on barriers and drivers to adoption of BIM revealed many barriers and drivers with differential significance by country (Walasek and Barszcz, 2017; Shaban et al., 2018; Ademci and Gundes, 2018; Elhendawi et al., 2019). A recent study undertaken by Elhendawi et al. (2019) on Kingdom of Saudi Arabian AEC sector where BIM adoption barriers were assessed considering six different categories (personal, technical, business, process, market and organisational barriers). The study holistically revealed personal challenges as the significant barriers to the deployment of BIM. These personal challenges are dominated by a lack of understanding of BIM and its benefits, resistance to change, and lack of BIM education and skills. Similarly, few studies from Nigeria revealed some barriers to BIM adoption (Wang, 2015; Onungwa et al., 2017), but not to common professionals or wide market (macro scale). It is therefore difficult to appraise (at market level) the challenges required to be resolved and drivers to persuade the BIM adoption in the Nigerian construction industry.

As an extended conference paper (Hamma-adama and Kouider, 2019), this study attempts to fill a gap of differentiating by order of importance, the common barriers and drivers toward BIM adoption from adopters and non-adopters perspectives within the Nigerian construction market. The investigation was set to be achieved through a critical review of literature where potential barriers and drivers for BIM adoption were identified; then ranked by order of significance, and evaluate the adopters and non-adopters perspectives (i.e. the percentage of disagreement). This will allow an informed decision in the development of a strategy to effective BIM adoption within the Nigerian construction market.

2. Literature review:

BIM is amongst the most discussed subjects in the Architecture Engineering and Construction (AEC) industry, and perhaps the most discussed area of development in the AEC process. There is a huge development in research and efforts to implement this new innovative process. Hjelseth (2017) compiled five years of publications (2013-2017) from Automation in Construction in the field of BIM; his statistics revealed high (>70%) concentration on interoperable technology perspective than collaborative processes. The study suggests more research on awareness of real understanding and how BIM influences AEC activities. On the other hand, some investigators believed that researchers had concentrated mostly on adoption and non-adopters, investigating the barriers and drivers, development of models and frameworks (Hosseini et al., 2016); albeit there is an irregularity in the adoption as well as the implementation across the globe and different disciplines.

There are several investigations and studies on BIM development and usage around the globe. McAuley et al. (2016) mapped the global overview of BIM adoption; Africa is the only continent who does not have representation. Remarkably, there are case studies to learn from at country levels, particularly the countries' BIM adoption trends. Several countries around the world have been striving to preserve the digital shift, for example, USA, UK, Australia, Singapore, South Korea, Denmark, Russia and Finland to mention but a few (McAuley et al., 2016). These countries happened to have bodies that survey the BIM adoption and provide Noteworthy BIM Publications (NBPs) to maintain guide and keep track of the BIM progress. Bodies like BIM Innovation Capability Programme (BICP) – Ireland; National BIM Reports by National Building Specifications – UK; NATSPEC – Australia; and SmartMarket Report by McGraw Hill Construction – USA are examples of these bodies. For a global assessment of BIM adoption and its business value, McGraw Hill Construction remains the only source of NBPs (McAuley et al., 2016).

In the recent academic discussion, there are several investigations on the social aspect of BIM adoption; such as readiness, awareness, level of adoption, capabilities (stages) as well as barriers and driver toward the adoption and implementation of the BIM (Ademci and Gundes, 2018). Such efforts (by countries and organizations) played a significant role in

revolutionizing the BIM adoption process (Mustaffa et al., 2017). Subsequent studies on BIM adoption challenges revealed consistent trend, from Walasek and Barszcz (2017) to Ademci and Gundes (2018), Sun et al. (2017) and Tan et al. (2019). These studies brought about describing, categorizing, and ranking of barriers against the BIM adoption.

Wang (2015) study also compiled and ranked some challenges faced by Mechanical, Electrical and Plumber (MEP) firms in Nigeria. The study reveals that lack of technical expertise on BIM tools utilization, lack of awareness of BIM technology as well as high cost of investment on staff training, process change, software and hardware upgrade as the most critical barriers to BIM adoption. While Onungwa et al. (2017) revealed lack of skilled personnel, internet connectivity, the reluctance of other stakeholders to use BIM, lack BIM object libraries, and lack of awareness of the technology as the main barriers against BIM adoption. On common grounds, most studies cited and identified challenges in the lack of trained personnel. They are abreast of the latest development in technology also lamented the BIM knowledge gap where most Architects learn on the job, as no training is mostly offered to them.

In the NBS report (2018), barriers to BIM adoption were reported under two umbrellas, internal (i.e. lack of training, expertise and funds to invest), and external (i.e. lack of BIM demand by the client and lack of large projects that necessitate the BIM deployment). While, the most recent compiled barriers by Ademci and Gundes (2018) were grouped into five categories; these include personal, legal, management, cost, and technical for convenience while carrying out analysis (Sun et al. 2017). Sun et al. (2017) compiled a total of twenty-two BIM adoption barriers; however, that does not necessarily apply to the entire professional fields, organizations, and countries as common. For example, the UK reported 18 barriers in their continuous BIM assessment survey (NBS 2018, p. 35), and these barriers are not exactly as those extracted by Sun et al. (2017) or those by Wang (2015). Though, there are some similarities and common terms across the lists. For example, Khosrowshahi and Arayici (2012) reported many barriers to adopt BIM across the UK, and assert that those barriers are commonly on organizational readiness. Table 1 summarizes the compiled barriers to BIM adoption from across organizations and countries.

Table 1: Barriers to BIM adoption

S/No.	Barriers to BIM adoption	Reference
1	Lack of expertise within the organizations	Aouad et al., 2006; Yan and Damian, 2008; Arayici et al., 2009; Lindblad, 2013; Wang et al., 2015; Saleh, 2015; Ahmed et al., 2018; Jamal et al., 2019; Tan et al., 2019
2	Lack of expertise within the project team	Saleh, 2015; Wang et al., 2015; Jamal et al., 2019; Tan et al., 2019
3	Lack of standardization and protocols	BCIS, 2011; Wang et al., 2015; Ahmed et al., 2018; Jamal et al., 2019; Tan et al., 2019
4	Lack of collaboration among stakeholders	BCIS, 2011; Wang et al., 2015; Tan et al., 2019
5	High Investment Cost	Yan and Damian, 2008; Coates et al., 2010; Giel et al., 2010; Thompson and Miner, 2010; Azhar, 2011; Efficiency and Reform Group, 2011; Lee et al., 2012; Crotty, 2012
6	Legal issues around ownership, IP & PI insurance	Christensen et al., 2007; Furneaux and Kivvits, 2008; Arayici et al., 2009; Chao-Duivis, 2009; Azhar, 2011; Oluwole, 2011; UK BIM Industry Working Group, 2011; Udom, 2012; Race, 2012; Jamal et al., 2019;
7	Lack of client demand	BCIS 2011; Zuhairi et al. 2014; Saleh, 2015; Wang et al., 2015; Jamal et al., 2019
8	Lack of infrastructure	Wang et al., 2015
9	Lack of government policy	Wang et al., 2015; Elhendawi, A.I.N., 2018
10	Industry's Cultural resistance	Jordani, 2008; Mihindu and Arayici, 2008; Yan and Damian, 2008; Rowlinson et al, 2009; Watson, 2010; Arayici et al., 2011
11	Lack of additional project finance to support BIM	Arayici et al., 2009; Jamal et al., 2019
12	Resistance at the operational level	Jamal et al., 2019
13	The reluctance of team members to share information	Yan and Damian, 2008; Arayici et al., 2009; Wang et al., 2015
14	Return on Investment (ROI) issue	Coates et al., 2010; Arayici et al., 2011; Lee et al., 2012

The lack of expertise, training and cost of the tools are consistently remaining amongst the significant barriers to BIM adoption across some countries. Countries like the UK (NBS,

2018; NBS, 2017 NBS, 2013), Malaysia (Jamal et al., 2019) and Nigeria (Wang, 2015; Onungwa et al., 2017; Abubakar et al., 2014) are examples of that. In the UK, a lack of expertise is attributed to the low performance of the Higher Education Institutions (HEIs). Moreover, the low levels of engagement between the HEIs and the industry appear the major issue (Underwood et al., 2015). While in Nigeria, students are generally trained on 'file-based collaboration' – 2D and 3D CAD and HEIs are not technically ready to offer the BIM training at all (Hamma-adama et al., 2018).

The drivers to adopt innovation are merely the facilitators to adopt a new product or process (Saleh, 2015). The facilitators are the enablers as resolving the barriers ease the adoption of innovation; the same way the drivers support the adoption process. Potential drivers mostly fall under empowerment, leadership, and creative culture; and most barriers are interlinked with drivers. In most circumstances, the motivator is achieved by removal of a barrier. For example, resolving the lack of experts or trained personnel on BIM means providing training on BIM. Table 2 below summarizes some potential drivers from previous studies.

Table 2: Drivers to BIM adoption

S/No.	Drivers to BIM adoption	Reference
1	Availability of trained professionals to handle the tools	McDonald, 2012; Kiani et al., 2015; Saleh, 2015; Badrinath et al., 2016
2	BIM Software affordability	Oladapo, 2007; Macdonald, 2012; Eadie et al., 2013
3	Enabling environment within the industry	Oladapo, 2007; Takim et al., 2013
4	Clients' interest in the use of BIM in their projects	Liu et al., 2010; BCIS 2011; Eadie et al., 2013; Lee & Yu, 2013; Takim et al., 2013; Saleh, 2015
5	Awareness of the technology among industry stakeholders	Oladapo, 2007; Zikic, 2009; Saleh, 2015
6	Cooperation and commitment of professional bodies to its implementation	Oladapo, 2007; Becerik-Gerber et al., 2011
7	Proof of cost savings by its adoption	Newton & Chileshe, 2012; Eadie et al., 2013; Demirdoven, 2015; Saleh, 2015
8	Cultural change among industry stakeholders	Kiani et al., 2015; Saleh, 2015
9	Government support through legislation	Efficiency and Reform Group, 2011; buildingSMART Australasia, 2012; Eadie et al., 2013; Zuhairi et al., 2014; Kiani et al., 2015; Saleh, 2015; Natalija et al., 2019
10	Collaborative Procurement methods	Sinclair, 2012

3. Research Methodology:

A literature review was adopted in identifying potential barriers and drivers for BIM adoption. That serves as precedent and baseline to the study; primary data is also involved in this study and was collected within five months period. An online questionnaire survey was used as a tool for data collection. To determine the target population, interested parties were quite insignificant as the study subject awareness appears low (Hamma-adama et al., 2018b). A mixture of purposeful sampling and snowball method was adopted in the sampling and data collection procedure. The purposeful sampling was adopted to allow the researcher selects only the participants who possess the qualities necessary to provide meaningful input and reliable assessment of the study context (Coyne, 1997); and snowball was utilized in generating substantial (in both quality and quantity) responses (Noy, 2008). The purposeful sampling is adopted because; only those who are aware of or have knowledge of BIM are of interest in this study.

A quantitative research approach is adopted. A quantitative research method is used in achieving a wide coverage of the survey with a considerable response rate, bias free-response and free from privacy issues (Naoum, 2012). A structured questionnaire survey was used for the primary data collection. The questionnaire was designed mainly on two target enquiries, drivers and barriers to adoption of BIM in the Nigerian construction industry after determination of the respondent's demography. As it is set for a purpose, only those aware of BIM responses are accepted; thus, the system accepts the only target audience.

A reliability test, descriptive statistics and Relative Importance Index (RII) were subsequently deployed in the analysis of data. The reliability test was carried out in ascertaining the internal consistency of the scale of items used in the questionnaire. Descriptive statistics and RII were used in the determination of the most influential items for both adopters and non-adopters.

As for the respondents' profile, categorical data is generated while the main questions involved the use of a five-point Likert rating scale with five as the highest rank and one as the lowest. A five-point Likert rating scale is used with a standard method of ranking using Relative Importance Index (RII).

The relationship defines RII as:

$$\text{Relative Importance Index (RII)} = \frac{\Sigma W}{A \times N} \quad (0 \leq \text{index} \leq 1) \text{ (Eadie et al., 2013)}$$

where:
W= element weighting by the respondents using a number between 1 and 5. Considering 1 as the least significant variable, and 5 as the most significant variable;
A= highest weight; and

N= total number of respondents.

Subsequently, the BIM barriers and BIM drivers ranked by the respondents are examined in terms of their interaction with the BIM concept. Some have already adopted the concept, while some are still at the awareness stage. A comparison was carried out using the Rank Agreement Factor (RAF) to determine adopters and non-adopters level of agreement or disagreement to the respective rankings by the group of adopters and non-adopters.
The following relationships define RAF:

And, maximum RAF (RAFmax) is then evaluated with:
Where;
Ri,1 is the rank of item i in group 1,
Ri,2, is the rank of item i in group 2,
N is the total number of items, which is the same for each group,
Rj,2 is the rank of item j in group 2, and;
j = N – i + 1.
Percentage Disagreement (PD) between the two groups is the ratio of RAF to RAFmax, as expressed below:
While the Percentage Agreement (PA) between the two ranked groups is the balance of percentage from the PD, which is:
PA = 100 – PD
A higher RAF value indicates a weaker agreement between the two groups. Thus, the RAF value of zero means a complete agreement between two subject groups. A spider diagram is plotted as in Fig. 3 and 4 to graphically illustrate the ranking variations by the two set groups.

4. Data collected, results and discussions:

The reliability test result, respondents' demographic information, descriptive statistics on the barriers and the drivers as well as the important relative index are evaluated and presented below.

4.1 Reliability test

The reliability test is carried out to ascertain an internal consistency of the scale of items used in the questionnaire as well as the reliability of the questionnaire for further analysis. Thus, Cronbach's Alpha is adopted for the reliability analysis, and the results are compared with George & Malley's (2003) acceptability. Any coefficient of Cronbach's alpha that is greater than 0.6 is considered acceptable, as such, all the items are within acceptable limit with Cronbach's Alpha coefficient of 0.95 (see Table 3 and 4). Moreover, all values >0.7 are considered acceptable according to Pallant (2013); thus, Cronbach's alpha >0.9

indicated a high level of internal consistency of the measured items and mean values they are closely related.

Table 3: Reliability Test

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Availability of trained professionals to handle the tools	75.75	396.94	.68	.95
BIM Software affordability	76.09	396.80	.65	.95
Enabling environment within the industry	76.18	399.70	.69	.95
Clients interest in the use of BIM in their projects	76.15	391.14	.68	.95
Awareness of the technology among industry stakeholders	76.09	404.95	.59	.95
Cooperation and commitment of professional bodies to its implementation	76.16	397.78	.68	.95
Proof of cost savings by its adoption	75.94	406.62	.55	.95
Cultural change among industry stakeholders	76.54	402.52	.65	.95
Government support through legislation	76.51	389.18	.75	.95
Collaborative Procurement methods	76.46	394.25	.72	.95
Lack of expertise within the organizations	75.79	406.29	.52	.95
Lack of expertise within the project team	75.97	402.78	.58	.95
Lack of standardization and protocols	76.04	397.71	.69	.95
Lack of collaboration among stakeholders	76.26	398.23	.70	.95
High Investment Cost	76.35	393.81	.71	.95
Legal issues around ownership, IP & PI insurance	76.69	397.38	.68	.95
Lack of client demand	76.21	398.20	.59	.95
Lack of infrastructure	76.40	394.21	.67	.95
Lack of government policy	76.24	391.41	.71	.95
Industry's Cultural resistance	76.31	401.95	.64	.95
Lack of additional project finance to support BIM	76.24	394.84	.72	.95
Resistance at the operational level	76.62	405.82	.57	.95
The reluctance of team members to share information	76.26	398.74	.75	.95
Return on Investment (ROI) issue	76.60	401.86	.64	.95

Table 4: Reliability Alpha Value

Reliability Statistics	
Cronbach's Alpha	N of Items
.95	24

4.2 Demographic profile of respondents

Table 5 presents the details of the respondents participated in the study or survey. The details include their location of practice in Nigeria, years of experience in the industry, size of their organizations, profession, specialization and their highest educational qualification.

Table 5: Analysis of socio-economic variables (Source: field survey, 2018.)

Variable	**Characteristics**	**Freq.**	**Percentage (%)**	**Total**
Location of practice	North-Central	26	38.2	
	North-East	11	16.2	
	North-West	16	23.5	
	South-East	2	2.9	
	South-South	4	5.9	
	South-West	9	13.2	68
Years of practice	< 5 years	14	20.6	
	5 - 10 years	27	39.7	
	11 - 15 years	15	22.1	
	> 15 years	12	17.6	68
Number of employees	< 10 personnel (Micro)	29	42.6	
	10 - 50 personnel (Small)	29	42.6	
	50 - 200 personnel (Medium)	7	10.3	
	> 200 personnel (Large)	3	4.4	68
Profession	Architecture	16	23.5	
	Building Engineering	1	1.5	
	Civil/Structural Engineering	30	44.1	
	Electrical Engineering	8	11.8	
	Mechanical Engineering	4	5.9	
	Construction Management	1	1.5	
	Quantity Surveying	7	10.3	
	Other:	1	1.5	68
Specialization	Contractor/Construction	19	27.9	
	Designer or Consultant	41	60.3	
	Client	4	5.9	
	Development Authority	4	5.9	68
Highest qualification	OND or HND	2	2.9	
	B.Sc./B.Tech./B Eng.	34	50.0	
	MSc/M.Eng.	25	36.8	
	PhD	7	10.3	68

There are considerably higher respondents from four out the six zones, this happened due to a higher number of researchers' network, and a considerable number of firms and construction works within North-Central and South-West specifically. The predominant respondents are having 5 to 15 years of experience in the industry and mostly (about 80%)

came from micro (<10 personnel) and small (10 – 50 personnel) firms. In the case of their professions, specialities and educational qualifications, over 60% of them came from Architectural and Civil/Structural engineering backgrounds and working as designers/consultants and contractors. In addition, more than 80% are first degree (B.Sc./B.Tech./B.Eng) and second-degree (MSc/M.Eng.) holders.

4.3 BIM awareness and usage

This aspect involves the evaluation of the proportion of those using BIM from those aware but not using the concept. Note that all the respondents are only those aware of BIM; whether they use it or not. Thus, the percentages reflect only within the targeted group (who are aware of BIM). A significant shift can be a notice from the 2017 survey, and this indicated a substantial increase in the awareness and usage within the market (see Fig. 1 below). The proportion of users to awareness increased from 28%:72% to 54%:46% (Fig. 2) based on those aware of BIM.

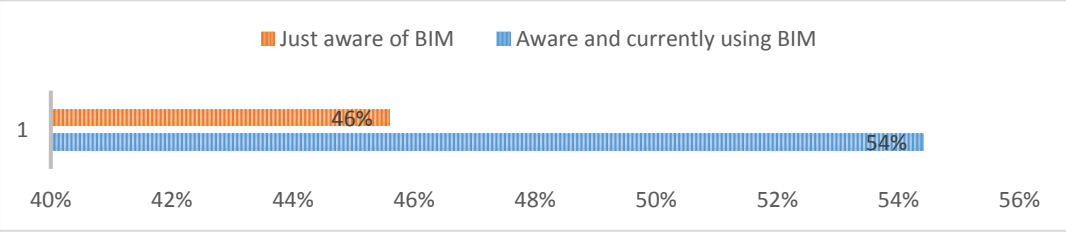

Fig. 1. BIM awareness and usage (Source: field survey, 2018.)

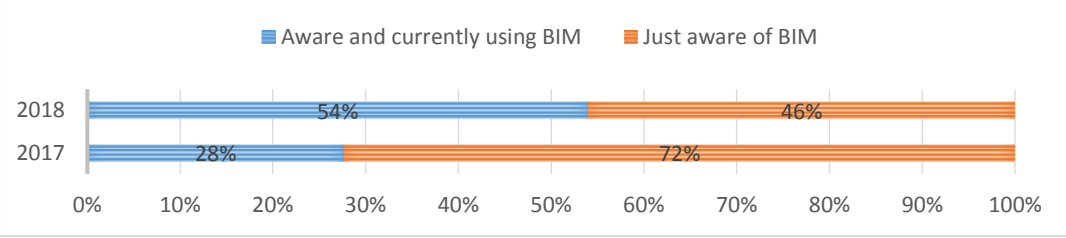

Fig. 2. BIM awareness and usage for 2017 and 2018

4.4 Barriers to BIM adoption in Nigeria

Subjecting the fourteen generated barriers to BIM adoption in Nigeria into RII (see table 6 below) using the scale of 1-5 (Likert scale), it is realised that, the 1st ninth-ranked barriers are the most significant (RII ≥ 0.70) or mean ≥3.5 in a five-point Likert scale (Badu et al., 2012).

The result, in general, indicated lack of expertise within the organizations, lack of expertise within the project team, lack of standardization and protocols, and lack of client

demand as the most influential barriers (1st to 4th) respectively. Moreover, ranked the following as 5th: lack of government policy, lack of additional project finance to support BIM, lack of collaboration among stakeholders and reluctance of team members to share information.

Table 6: RII and ranking of barriers against BIM adoption in Nigeria

Number of Rank R & Weighted value W impact	**Weight 5**	**Weight 4**	**Weight 3**	**Weight 2**	**Weight 1**	**Total**	**Σ W**	**RII**	**Rank**
Lack of expertise within the organizations	110	92	39	10	5	68	256	0.75	1
Lack of expertise within the project team	90	92	42	14	6	68	244	0.72	2
Lack of standardization and protocols	85	76	63	8	7	68	239	0.70	3
Lack of client demand	95	60	42	22	9	68	228	0.67	4
Lack of government policy	85	80	27	24	10	68	226	0.66	5
Lack of additional project finance to support BIM	75	64	63	16	8	68	226	0.66	5
Lack of collaboration among stakeholders	55	88	51	24	6	68	224	0.66	5
The reluctance of team members to share information	40	100	57	22	5	68	224	0.66	5
Industry's Cultural resistance	50	80	60	26	5	68	221	0.65	9
High Investment Cost	80	44	60	26	8	68	218	0.64	10
Lack of infrastructure	60	84	42	16	13	68	215	0.63	11
Return on Investment (ROI) issue	40	48	75	30	8	68	201	0.59	12
Resistance at the operational level	30	56	81	24	9	68	200	0.59	12
Legal issues around ownership, IP & PI insurance	50	36	63	36	10	68	195	0.57	14

These barriers were analyzed further to balance the perceptions by the BIM adopters and the non-adopters. Table 7 presents the two group rankings. From the first glance on radar plot (Fig. 3), adopters ranking was quite simultaneous, indicating a higher level of reality and consistency. At the same time, non-adopters are a sort of zig-zag manner (ranking whether very high or very low). This pattern suggests that while adopting BIM, perception to barriers change as the realities unfold or became dominant. The barriers ranked 1st, 2nd, 3rd and 4th by non-adopters, were ranked 2nd, 6th, 9th and 1st by adopters with quite lower average index, as such what is perceived most influential barriers before adoption tend to change after adoption; such challenges may have been dealt with in the adoption process.

Table 7: Variation of barriers ranking among adopters and non-adopters

BARRIERS	**Adopters**		**Non-adopters**	
	RII	Rank	RII	Rank
Lack of standardization and protocols	0.74	1	0.66	4
Lack of expertise within the organizations	0.72	2	0.79	1
Industry's Cultural resistance	0.69	3	0.60	11
Lack of additional project finance to support BIM	0.69	3	0.64	9
Lack of client demand	0.68	5	0.66	4
Lack of expertise within the project team	0.67	6	0.77	2
Lack of government policy	0.67	6	0.66	4
Lack of collaboration among stakeholders	0.66	8	0.66	4
Resistance at the operational level	0.65	9	0.52	14
The reluctance of team members to share information	0.65	9	0.67	3
High Investment Cost	0.64	11	0.64	8
Lack of infrastructure	0.63	12	0.63	10
Return on Investment (ROI) issue	0.59	13	0.59	12
Legal issues around ownership, IP & PI insurance	0.57	14	0.58	13
Average RII	**0.66**		**0.65**	

On the other hand, they quite agreed over half of the barriers as to their significance or indexes. For instance, High Investment Cost, Lack of infrastructure, and Return on Investment (ROI) issue are scored the same magnitude although they were in different ranks. This situation leads to the determination of PD and PA to allow us to drive exclusive findings.

Table 8 presents the evaluation of the PD and PA. The result reveals 49.48% PD and 50.52% PA, means both groups have approximately 50:50 agreement to disagreement, in other words, they agreed on half (50%) of the ratings and disagreed on the other half (50%). Conclusively, this indicates that the adopters are still at the infancy stage as their PA is still high (50%). Higher PA does not go with the findings from (Eadie et al., 2014) that "…BIM adopters change their views on the most significant barriers to BIM after implementation by ranking them differently than those yet to adopt BIM" (Eadie et al., 2014 p. 92). Moreover, the average of 0.66 and 0.65 RII of adopters and non-adopters (respectively) indicated a small difference to their perception of BIM adoption barriers. Thus, confirmed that the country is at the early stage of BIM adoption...

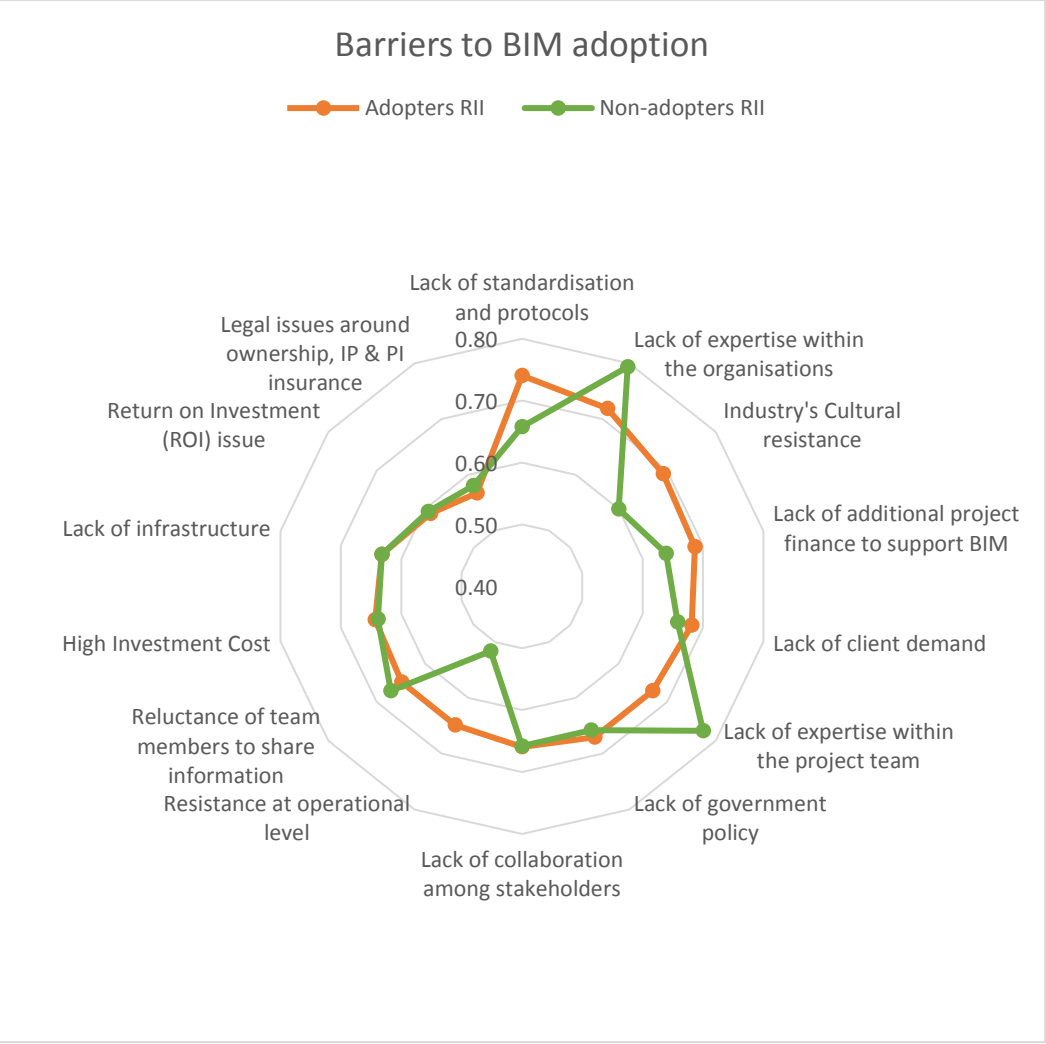

Fig. 3. Variation of barriers ranking among adopters and non-adopters (Source: field survey, 2018.)

Succinctly, nine of the fourteen barriers are significantly crucial to both the adopters and non-adopters; however, the remaining five appeared less important to both groups. These five barriers are resistance at the operational level, high investment cost, lack of infrastructure, return on investment (ROI) issue as well as legal issues around ownership, IP & PI insurance.

Table 8: RAF, PD and PA values for BIM barriers

BARRIERS	BIM Users	BIM Non-users					
	Rank (Ri1)	Rank (Ri2)	Ri1-Ri2	Absolute of Ri1-Ri2	Rj2 = Ri2 corresponds to (N-Ri1+1) from Ri1	Ri1-Rj2	Absolute of Ri1-Rj2
Lack of standardisation and protocols	1	4	-3	3	13	-12	12
Lack of expertise within the organisations	2	1	1	1	12	-10	10
Industry's Cultural resistance	3	11	-8	8	10	-7	7
Lack of additional project finance to support BIM	3	9	-6	6	10	-7	7
Lack of client demand	5	4	1	1	3	2	2
Lack of expertise within the project team	6	2	4	4	14	-8	8
Lack of government policy	6	4	2	2	14	-8	8
Lack of collaboration among stakeholders	8	4	4	4	4	4	4
Resistance at the operational level	9	14	-5	5	2	7	7
The reluctance of team members to share information	9	3	6	6	2	7	7
High Investment Cost	11	8	3	3	9	2	2
Lack of infrastructure	12	10	2	2	11	1	1
Return on Investment (ROI) issue	13	12	1	1	1	12	12
Legal issues around ownership, IP & PI insurance	14	13	1	2	4	10	10
			Absolute Sum	48		Absolute Sum	97
			RAF	3.43		RAF MAX	6.93
			PD	49.48%		PA	50.52%

4.5 Drivers to BIM adoption in Nigeria

Subjecting the ten generated drivers to BIM adoption in Nigeria into RII (see Table 8) using the scale of 1-5 (Likert scale), it was realized that, the 1st seventh-ranked drivers are the most significant (RII $\geq$ 0.70) or mean $\geq$3.5 in a five-point Likert scale (Badu et al., 2012). The most influential drivers revealed as availability of trained professionals to handle the tools, proof of cost savings by its adoption, BIM Software affordability and awareness of the technology amongst industry stakeholders (in descending order). Moreover, ranked the following as 5th: clients' interest in the use of BIM in their projects, cooperation and commitment of professional bodies to its implementation, and enabling environment within the industry.

Table 9: RII and ranking of drivers against BIM adoption in Nigeria

Number of Rank R & Weighted value W impact	Weight 5	Weight 4	Weight 3	Weight 2	Weight 1	Total	∑ W	RII	Rank
Availability of trained professionals to handle the tools	130	84	24	16	5	68	259	0.76	1
Proof of cost savings by its adoption	85	88	57	12	4	68	246	0.72	2
BIM Software affordability	90	84	36	18	8	68	236	0.69	3
Awareness of the technology among industry stakeholders	70	84	57	22	3	68	236	0.69	3
Clients interest in the use of BIM in their projects	115	48	45	12	12	68	232	0.68	5
Cooperation and commitment of professional bodies to its implementation	80	72	48	26	5	68	231	0.68	5
Enabling environment within the industry	60	92	48	26	4	68	230	0.68	5
Collaborative Procurement methods	45	84	54	16	12	68	211	0.62	8
Government support through legislation	65	64	42	22	14	68	207	0.61	9
Cultural change among industry stakeholders	20	92	54	32	7	68	205	0.60	10

These drivers were analyzed further to balance the perceptions by both the adopters and non-adopters. Table 10 presents the two group rankings. From the first glance on radar plot (Fig. 4), the adopters ranking was simultaneous, indicating a higher level of reality and consistency. At the same time, the non-adopters are a sort of zigzag at some points (ranking very high and very low). This suggests that while adopting BIM, perception to driving the adoption changes. The drivers ranked 1st, 2nd, 3rd and 4th by the non-adopters are ranked 1st, 8th, 5th and 2nd by the adopters. Furthermore, with a tiny difference of average RII as such, what is perceived most influential drivers before adoption tend to change after the adoption.

On the other hand, the average RII of 0.68 and 0.67 for the adopters and the non-adopters respectively revealed that the adopters are still at an early stage, so they perceive the drivers' influence the same way with the non-adopters.

Table 10: Variation of drivers ranking among adopters and non-adopters

DRIVERS	Adopters		Non-adopters	
	RII	Rank	RII	Rank
Availability of trained professionals to handle the tools	0.76	1	0.77	1
Proof of cost savings by its adoption	0.74	2	0.70	4
Clients interest in the use of BIM in their projects	0.70	3	0.66	6
Enabling environment within the industry	0.69	4	0.66	6
Awareness of the technology among industry stakeholders	0.68	5	0.71	3
Cooperation and commitment of professional bodies to its implementation	0.68	5	0.68	5
Cultural change among industry stakeholders	0.66	7	0.54	10

BIM Software affordability	0.65	8	0.74	2
Collaborative Procurement methods	0.65	8	0.59	8
Government support through legislation	0.61	10	0.61	8
Average RII	**0.68**		**0.67**	

Notwithstanding, they nearly have the same average RII, the adopters disagree a bit more than they agree with the non-adopters in terms of individual drivers' influence to adopt BIM (Table 10). To demonstrating this scenario, availability of trained professionals to handle the BIM tools, cooperation and commitment of professional bodies to BIM implementation and Government support through legislation are drivers that scored the same and rated the same to moving the adoption further by both the adopters and non-adopters. This finding suggests persistent investment on the drivers to drive the BIM adoption further.

Table 10 presents the evaluation of the PD and PA. The result reveals more justification of early adoption stage as shown by the study on the barriers. The PD is found to be 58.82%, and the PA is 41.18%. It means both groups have nearly 40:60 agreement to disagreement; in other words, they agreed on 4 out of 10 (40%) of the drivers' scoring and disagreed on the remaining 6 out of the 10 (60%) drivers' scoring.

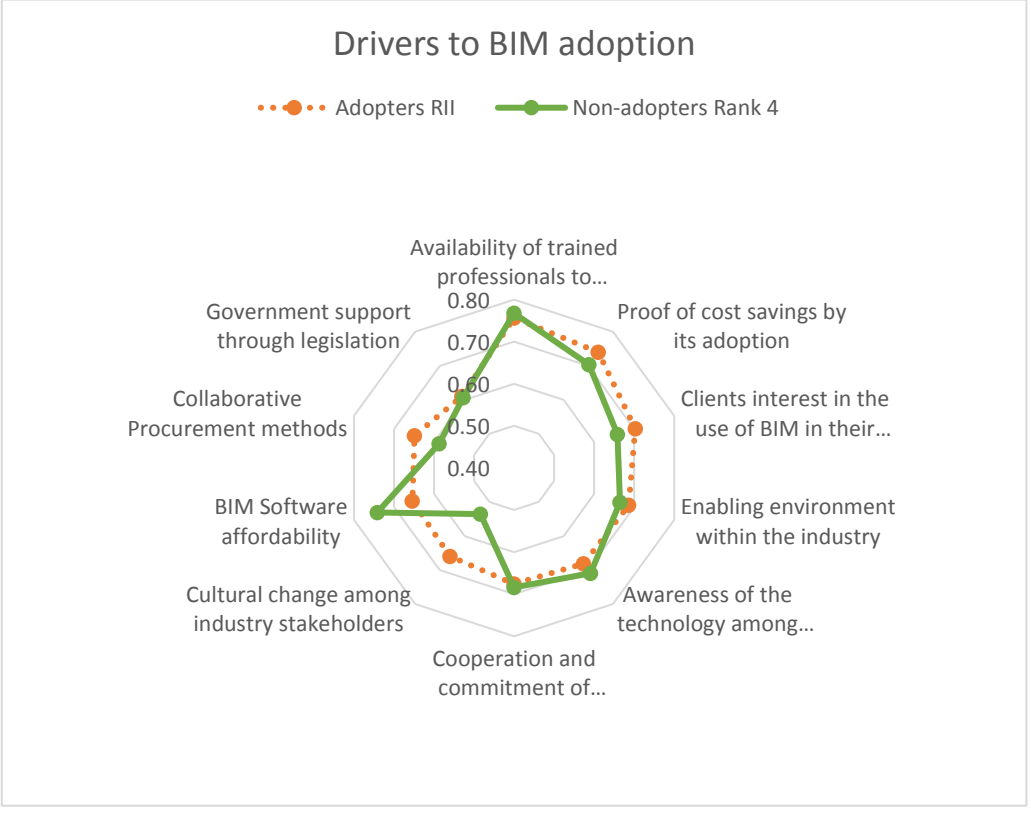

Fig. 4. Variation of drivers ranking among adopters and non-adopters (Source: field survey, 2018.)

Succinctly, all the drivers are of high importance to both the adopters and non-adopters in the exception of three who appear less compared to the rest. These three drivers are cultural change among industry stakeholders, collaborative procurement methods and government support through legislation.

Table 10: RAF, PD and PA values for BIM Drivers

DRIVERS	**BIM Users**	**BIM Non-users**					
	Rank (R1)	Rank (R2)	R*i*1-R*i*2	Absolute of R*i*1-R*i*2	R*j*2 = R*i*2 corresponds to (N-R*i*1+1) from R*i*1	R*i*1-R*j*2	Absolute of R*i*1-R*j*2
Availability of trained professionals to handle the tools	1	1	0	0	8	-7	7
Proof of cost savings by its adoption	2	4	-2	2	8	-6	6
Clients interest in the use of BIM in their projects	3	6	-3	3	2	1	1
Enabling environment within the industry	4	6	-2	2	10	-6	6
Awareness of the technology among industry stakeholders	5	3	2	2	5	0	0
Cooperation and commitment of professional bodies to its implementation	5	5	0	0	5	0	0
Cultural change among industry stakeholders	7	10	-3	3	6	1	1
BIM Software affordability	8	2	6	6	6	2	2
Collaborative Procurement methods	8	8	0	0	6	2	2
Government support through legislation	10	8	2	2	1	9	9
			Absolute Sum	20		Absolute Sum	34
			RAF	2.00		RAF MAX	3.40
			PD	58.82%		PA	41.18%

5. Conclusions:

The urgent need for BIM adoption in construction industry is providing huge opportunities in research and development. However, researches in barriers and drivers to its adoption did not yield fetched universal adoption thus, that leaves a question of inadequacy or misrepresentations. There are several findings on barriers and drivers to BIM adoption from literatures; many of which having different influence over the other. Nigeria is among developing countries where BIM is becoming vibrant; however, BIM adoption in Nigeria remains in its infancy. This piece of research is aim at filling the gap of differentiating by order of importance, the common barriers vis-a-vis to drivers toward

BIM adoption in the Nigerian construction market. Fourteen barriers and ten drivers were identified from literature, five Likert scale was used for measurement of respondents' perceptions and RII was used to rank the perceptions. The study revealed that barriers ranked from 1st to 9th are highly influential to the adoption of BIM in Nigeria, and the drivers ranked from 1st to 7th are significant to facilitate BIM adoption in Nigeria. Further evaluation was carried out in comparing the perception of those adopted BIM and those that have not. Ranking and scoring of barriers and drivers amongst adopters and non-adopters having nearly 50:50 PD to PA which suggests early adoption stage or low maturity stage. The common and most significant barriers and drivers were established from the two set groups. The common and significant barriers to adopters and non-adopters are: Lack of standardization and protocols, Lack of expertise within the organizations, Industry's Cultural resistance, Lack of additional project finance to support BIM, Lack of client demand, Lack of expertise within the project team, Lack of government policy, Lack of collaboration among stakeholders, and Reluctance of team members to share information. On the other hand, the common and most significant drivers to adopters and non-adopters are: Availability of trained professionals to handle the tools, Proof of cost savings by its adoption, Clients interest in the use of BIM in their projects, Enabling environment within the industry, Awareness of the technology among industry stakeholders, Cooperation and commitment of professional bodies to its implementation, and BIM Software affordability.

The study recommends that, to develop effective BIM adoption framework, the established barriers and drivers should be considered vital. The barriers should be resolved in totality, and drivers should be instigated, motivated and encouraged. Further face-to-face (interview) study is necessary to explore more and in-depth challenges of BIM adoption in the industry under study; and as the industry is getting more aware of the BIM, periodic evaluation of the critical barriers and drivers is vital. This study contributes to the body of knowledge in providing an in-depth understanding of barriers and drivers from adopters and non-adopters perspectives, their strengths of influence from the two groups and combined influence to adoption of BIM in the Nigerian construction industry.

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Closure Statement

At the end of this issue, we wish it is a good and a distinct issue, we would like to thank all those who contributed to its achievement since the first idea until today **30-06-2020**. Thanks to the BIMarabia Research Center, the publisher of the Journal. The International scientific board who led the review and follow-up and coordination over the whole last six months of effort to accomplish this work. Based on a sense of responsibility and passion for scientific research, we have provided every possible means to monitor research and scientific papers interested in the field of BIM, and its review followed up with the distinguished authors to reach the best scientific level. We promise you more valuable papers in the next issue. We also sincerely invite you to put forward your constructive views and suggestions for the development of the Journal. And a special invitation to contribute to the publication of your articles and research in the field of BIM and modern management and other areas covered by the Journal and mentioned at the beginning of the issue.